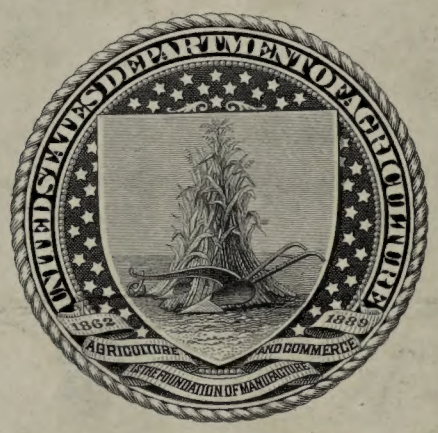
SUGGESTIONS AND COMMENTS ON BANANA GROWING AND SOME RELATED SUBJECTS

TELA, HONDURAS, DIVISION

B. T. GALLOWAY

JULY 6, 1927



Tela, Honduras.
May 2, 1927.

Mr. R. K. Thomas, Manager,
Tela Railroad Company,
Tela, Honduras.

Dear Mr. Thomas:

Before leaving Tela I want to thank you and through you the members of your staff for the many courtesies shown me. It has been a pleasure to note the keen way in which almost every conceivable phase of banana culture is discussed, argued, dissected and weighed by all your workers. This shows a fine spirit and a splendid morale. I have never experienced anything else like it.

When I return to Washington I shall assemble the data gathered and, after discussing some of the more pressing and important problems with our specialists, will submit a memorandum of suggestions. I hope by this means to bring to bear on some of the problems the wisdom and judgment of our specialists and experts. Now that I have seen the work of banana production and have gained direct knowledge of some of the problems, I hope in the future to be of assistance in effecting close contacts between workers here and specialists in the Department at Washington.

It has been my good fortune to have served the Department for forty years and I know from experience that my colleagues will always be glad to aid you when problems are presented in a specific and concrete way. After all, we regard the work of the United Fruit Company in the tropics as a great American enterprise; therefore, worthy of our full co-operation and support.

Sincerely yours,

(Signed) B. T. Galloway

cc Mr. R. H. Goodall
Mr. A. J. Chute
Mr. Wilson Popenoe

Tela, Honduras.
May 2, 1927.

Mr. H. K. Thomas, Manager,
Tela Railroad Company,
Tela, Honduras.

Dear Mr. Thomas:

Before leaving Tela I want to thank you and through you the members of your staff for the many courtesies shown me. It has been a pleasure to note the keen way in which almost every conceivable phase of banana culture is discussed, argued, dissected and weighed by all your workers. This shows a fine spirit and a splendid morale. I have never experienced anything else like it.

When I return to Washington I shall assemble the data gathered and, after discussing some of the more pressing and important problems with our specialists, will submit a memorandum of suggestions. I hope by this means to bring to bear on some of the problems the wisdom and judgment of our specialists and experts. Now that I have seen the work of banana production and have gained direct knowledge of some of the problems, I hope in the future to be of assistance in effecting close contacts between workers here and specialists in the Department at Washington.

It has been my good fortune to have served the Department for forty years and I know from experience that my colleagues will always be glad to aid you when problems are presented in a specific and concrete way. After all, we regard the work of the United Fruit Company in the tropics as a great American enterprise; therefore, worthy of our full co-operation and support.

Sincerely yours,

(Signed) B. T. Galloway

cc Mr. H. E. Goodell
Mr. A. J. Chute
Mr. Wilson Popenoe

SUGGESTIONS AND COMMENTS ON BANANA GROWING AND SOME RELATED SUBJECTS

TELA, HONDURAS, DIVISION

July 6, 1927.

Mr. R. K. Thomas,
Manager, Tela Railroad Co.,
Tela, Honduras.

Dear Mr. Thomas:

In compliance with my note to you, dated May 2, 1927, a copy of which is attached hereto, I am inclosing a memorandum entitled, "Suggestions and Comments on Banana Growing and Some Related Subjects - Tela, Honduras, Division."

From time to time suggestions and informative data will be sent to the several specialists at Tela whom it was my pleasure to meet.

I want to again thank you for the many courtesies shown me while at Tela, and to assure you that I shall be happy at all times to aid you in any way within my power.

Sincerely yours,

B. T. Galloway,
Plant Pathologist.

BTG.MMB

cc Mr. Geo. P. Chittenden
Mr. R. H. Goodell
Mr. Wilson Popenoe

July 6, 1927.

Mr. R. K. Thomas,
Manager, Tela Railroad Co.,
Tela, Honduras.

Dear Mr. Thomas:

In compliance with my note to you, dated May 2, 1927, a copy of which is attached hereto, I am inclosing a memorandum entitled, "Suggestions and Comments on Banana Growing and Some Related Subjects - Tela, Honduras, Division."

From time to time suggestions and informative data will be sent to the several specialists at Tela whom it was my pleasure to meet.

I want to again thank you for the many courtesies shown me while at Tela, and to assure you that I shall be happy at all times to aid you in any way within my power.

Sincerely yours,

B. T. Galloway,
Plant Pathologist.

BTG.MMB

cc Mr. Geo. P. Chittenden
Mr. R. H. Goodell
Mr. Wilson Popenoe

SUGGESTIONS AND COMMENTS ON BANANA GROWING AND SOME RELATED SUBJECTS

TELA, HONDURAS, DIVISION

Through the courtesy of the United Fruit Company, an opportunity was afforded for visiting the banana plantations of the Tela, Honduras, Division, with an incidental trip to Guatemala, including Guatemala City, Antigua and vicinity, and the banana plantations near Quirigua. We arrived at Tela April 16, 1927 and left on May 9. We arrived at Puerto Barrios May 10 and spent five days in Guatemala, sailing for home May 15.

INTRODUCING AND TESTING NEW AND PROMISING CROPS

It is gratifying to note the progress made in systematic plant introduction and testing at the Lancetilla Station near Tela. Considering the short time this work has been under way, the advances have been rapid. The location at Lancetilla seems almost ideal for the kind of work involved. The growth of many crops like bamboos, mangoes, avocados, lychees, and citrus compares favorably with what we have seen in other parts of the world.

Aside from the direct benefit of such work, too much emphasis can not be placed on its indirect or potential value. A crop that shows little promise at the outset may eventually prove of great value. This has been proved time after time in our own work in the Department of Agriculture. It would appear, therefore, that a broad program, looking toward the gradual development of this type of work so as to make it applicable to all the Central American divisions, is well worthy of consideration.

Plant Introduction and testing of new and promising crops is one of the oldest of horticultural practices, but its value can be greatly enhanced by systematic studies of the needs involved, followed by careful testing and consideration of the broader economic questions at issue. An organization

SUGGESTIONS AND COMMENTS ON BANANA GROWING AND SOME RELATED SUBJECTS

TELA, HONDURAS, DIVISION

Through the courtesy of the United Fruit Company, an opportunity was afforded for visiting the banana plantations of the Tela, Honduras, Division, with an incidental trip to Guatemala, including Guatemala City, Antigua and vicinity, and the banana plantations near Quirigua. We arrived at Tela April 16, 1927 and left on May 9. We arrived at Puerto Barrios May 10 and spent five days in Guatemala, sailing for home May 15.

INTRODUCING AND TESTING NEW AND PROMISING CROPS

It is gratifying to note the progress made in systematic plant introduction and testing at the Lancetilla Station near Tela. Considering the short time this work has been under way, the advances have been rapid. The location at Lancetilla seems almost ideal for the kind of work involved. The growth of many crops like bamboos, mangoes, avocados, lychees, and citrus compares favorably with what we have seen in other parts of the world.

Aside from the direct benefit of such work, too much emphasis can not be placed on its indirect or potential value. A crop that shows little promise at the outset may eventually prove of great value. This has been proved time after time in our own work in the Department of Agriculture. It would appear, therefore, that a broad program, looking toward the gradual development of this type of work so as to make it applicable to all the Central American divisions, is well worthy of consideration.

Plant introduction and testing of new and promising crops is one of the oldest of horticultural practices, but its value can be greatly enhanced by systematic studies of the needs involved, followed by careful testing and consideration of the broader economic questions at issue. An organization

such as the United Fruit Company must necessarily look a long way ahead in shaping its plans and policies for future growth and permanent remunerative returns. The economics of agriculture are rapidly changing all over the world. The increasing cost and instability of labor, the rapid decrease of virgin lands, the exhaustion of soils, and the cumulative effects of diseases and pests, all conspire to make it well worth while to plan a long way ahead for meeting the difficulties bound to arise. Plant introduction may not provide a substitute crop of the economic importance of the banana, but it may materially aid in stabilizing the banana industry and the organization around which the industry is built, through the utilization of land no longer available for bananas and which, for many reasons, can not be abandoned to the jungle. And then there is the important question of securing crops which may be fitted into plans looking toward the continued enrichment and improvement of the soil where bananas are the major crop and where indications point to their maintaining this status for a long time. In the Oriental tropics the need of maintaining soil fertility and correcting unfavorable conditions through cover crops and green manures has been recognized and steps are being taken to meet the situation. As we shall point out later, cover crops may become an important factor in disease control.

SPECIFIC SUGGESTIONS REGARDING SOME NEW CROPS

WOOD OIL - Wood oil or tung oil is a product used in the paint and varnish trade. The principal source of this material is China. The importation of oil into the United States amounts to about $10,000,000 a year. There is no tariff on the oil. At the beginning of 1927 indications pointed to a shortage in the wood-oil supply from China. This was further emphasized by

the February shipments. Despite disturbed conditions, however, reports show that for the first four months of 1927, there were nearly 20,000,000 pounds of wood oil imported, or about the same amount as last year. The prices have varied from 20 to 28 cents per pound. The industry is not an organized one in China, the nuts being gathered and assembled in community centers where the oil is extracted. Florida is making headway in the planting of wood-oil trees, something over 2,000 acres being out at this time. The tree grown in Florida is known as Aleurites fordii. This does not seem to do well at Tela. Mr. Popenoe's experiments show that A. montana is more promising. In view of the situation in China and the increasing demand for the product, this would seem like an industry worthy of encouragement. One of the pressing and immediate needs is the assurance of a future supply of montana seed for propagating purposes. In all liklihood, the supply of seed from China for the next few years will be very limited. The methods of vegetative propagation being worked out by Mr. Butler are likely to be of much importance later.

RUBBER - The Hevea plantings at Lancetilla and elsewhere in the division offer some encouragement. With labor conditions as they exist in Honduras and with a rather long, cool and wet winter, it is questionable whether Hevea can be grown satisfactorily here as in other parts of the tropics. It is well worth while, however, to continue investigations with the plant so as to get all practical information as to its habits, differences in seedling types, behavior under different soils and environment, and also for the purpose of securing plant material that might be utilized in other more tropical divisions. The crucial test of the project will come several years hence, when tapping becomes necessary. Two species of rubber vine,

Cryptostegia grandiflora and C. madagascariensis, offer encouraging potential value as rubber producers. These plants are being tested in southern Florida and do fairly well there, although the winters are rather severe on them. There is good evidence that the Cryptostegias are well adapted to conditions in the Tela division. Both species lend themselves well to labor conditions and other factors existing at Tela. Machete harvesting, continuous cutting from the same roots from year to year, utilization of existing railways and rolling stock for bringing the raw material to a central place for extraction, and tank shipments of the latex to the States for refinement are some of the possibilities. The Cryptostegia rubber is said to be of fair quality and it has been found that it can be extracted by mechanical processes similar to those now in commercial use for extracting rubber from the Mexican Guayule plant, Parthenium argentea.

MANGOES, AVOCADOS AND LYCHEES - There would seem to be an opening for the culture of these fruits in the Division, especially at the western end near Progreso. The market for good mangoes in the State is growing, and Florida and nearby countries are not meeting the situation. The question of fruit flies and other pests must always be kept in mind, but if it can be shown that the districts where the fruits are grown are free from these insects, the entrance of the fruits would not, in all liklihood be barred. In other words, the development of any industries with fruits of this nature must have back of it the assurance of insect control and the reduction to a minimum of the liklihood of introducing dangerous pests into the United States. The lychee fruit offers less risk as an insect carrier, and it is believed it would find a ready market here, as it would not compete with other fruits. All the lychee trees seen around the division were remarkably vigorous and

Cryptostegia grandiflora and C. madagascariensis, offer encouraging potential value as rubber producers. These plants are being tested in southern Florida and do fairly well there, although the winters are rather severe on them. There is good evidence that the Cryptostegias are well adapted to conditions in the Tela Division. Both species lend themselves well to labor conditions and other factors existing at Tela. Machete harvesting, continuous cutting from the same roots from year to year, utilization of existing railways and rolling stock for bringing the raw material to a central place for extraction, and tank shipments of the latex to the States for refinement are some of the possibilities. The Cryptostegia rubber is said to be of fair quality and it has been found that it can be extracted by mechanical processes similar to those now in commercial use for extracting rubber from the Mexican Guayule plant, Parthenium argentatum.

MANGOES, AVOCADOS AND LYCHEES - There would seem to be an opening for the culture of these fruits in the Division, especially at the western end near Progreso. The market for good mangoes in the States is growing, and Florida and nearby countries are not meeting the situation. The question of fruit flies and other pests must always be kept in mind, but if it can be shown that the districts where the fruits are grown are free from these insects, the entrance of the fruits would not, in all likelihood be barred. In other words, the development of any industries with fruits of this nature must have back of it the assurance of insect control and the reduction to a minimum of the likelihood of introducing dangerous pests into the United States. The lychee fruit offers less risk as an insect carrier, and it is believed it would find a ready market here, as it would not compete with other fruits. All the lychee trees seen around the division were remarkably vigorous and

healthy, but they had set no fruit. This difficulty might be overcome by ringing or perhaps by other methods. The subject is one worthy of study as the lychee lends itself to long-distance shipments and would make quite a "talking card" if placed on our fruit stands. The avocado seems questionable as an industry unless ways could be found for preserving it.

BAMBOO - The whole of the Tela division, and especially the lands at the eastern end, are well adapted to bamboo culture. There is a good market at present for many kinds of bamboo poles and canes. The Orient supplies this market. The details of this matter have been discussed with Mr. Popenoe.

COVER CROP SEED GROWING - The ease with which some important cover crops like Crotalarias, cow peas, and soy beans grow at Lancetilla suggests the possibility of utilizing outlying lands for seed production. Cow pea seed has been bringing from $5.00 to $8.00 per bushel for several years, and the Crotalarias are attracting much attention. Questions of seasonal adaptability, methods of harvesting, storing and overcoming insect pests would all need to have careful consideration. The marketing situation would also need study before serious embarkation on projects such as the one here considered. Further discussion of cover crops is given under the wilt disease heading.

BANANA IMPROVEMENT THROUGH BUD SELECTION

The bud selection work with the Gros Michel banana, inaugurated something over a year ago at Tela by Mr. A. D. Shamel, of the U. S. Department of Agriculture, and now being carried forward by Mr. Wilson Popenoe, has progressed sufficiently to indicate the complexities of such an undertaking. Improvement of a plant like the banana through bud selection is a unique undertaking. Much work of this nature has been carried on with other plants. In fact, bud selection, either conscious or unconscious, is a practice long fol-

lowed by horticulturists growing both ornamental and fruit crops. The plants involved, however, with comparatively few exceptions, have been of a different type from the banana, but that should not detract from interest in the work or discourage undertakings looking toward improvement of the crop. Whatever the direct outcome may be of bud selection with the banana, I am confident that such studies, carefully planned and carried out, will well repay any reasonable effort in time and money through bringing about a better and more accurate knowledge of the life history and habits of the plant. This has been the history of all such work whenever and wherever undertaken. What may be called the by-products resulting from the work will well repay all reasonable efforts and expense in carrying it through.

There is no questioning the fact that Mr. Shamel's bud selection work with citrus fruits in California has been of major importance to the industry. To even attempt to enumerate the direct and indirect benefits would be beyond the scope of this memorandum. Whether such a feat can be accomplished with other crops remains to be determined, but it is certain that benefits will accrue, for the fundamental idea is to gain knowledge of the habits, response to environment and life functions of the plant to the end of increasing the quantity and quality of the product at decreased cost. We must not be understood as intimating that such work as Mr. Shamel has done and is doing can be reduced to mathematical formulae,-blue-printed as it were- then passed on to others for execution. Mr. Shamel is wholly original in this respect. Certain of his methods can be formulated, followed and made worth while, as already pointed out. Our suggestion as to this work is that it be regarded as a relatively long-time proposition; that it be kept largely in the hands of those who are trained in research and who can interpret results through the background of knowledge of plants and plant reactions to environment.

Mr. Shamel, in his recommendations setting forth proper procedure, has stressed the need of time and care in all the preliminary stages in developing the performance records. To this end two performance record plats are under observation, both in the western end of the Tela division. We make the suggestion that as soon as practicable other plats be brought into this work. This will reduce the hazards from blow-downs, will widen the range of environmental reactions and will begin to bring together valuable practical data as by-products of the selection work. Mr. Shamel, in his citrus improvement work, has carried from 8 to 10 widely scattered plats for ten or twelve years, something over 6,000 trees being involved. We recognize that a limiting factor here is the time and labor involved in making the great number of necessary measurements, weighings, etc. With this in mind, we believe it well worth while to insugurate an additional method of systematic selection based on what Mr. Shamel calls "estimates" rather than detailed measurements and records. We may designate this as systematic mass selection looking to the improvement of all new banana plantings. Mass selection would involve (1) a definition and an agreement as to type, the same to be determined by the combined judgment of a selected small group of experienced banana men; (2) adherence to the type so far as practicable in future plantings and replantings. It may be necessary to develop a special small group of men for the purpose of carrying through this mass selection work. There is scarcely an intensive plant industry anywhere in the world involving vegetative propagation where some form of mass selection is not consciously or unconsciously followed. It has been developed in perhaps its highest form by the great cut-flower industries of the United States, involving roses, carnations, violets and such things, also in the improvement of thousands of ornamentals

and with many fruits and vegetables. The white potato and sweet potato are common examples in the vegetable group.

Mass selection, properly organized and carried through, should (1) increase production; (2) improve quality; (3) develop greater vigor, and (4) possibly make for greater resistance to disease, although we believe selection for disease resistance should be considered separately. To carry through such a plan successfully would involve the assembling and growing of the selected material in nurseries and the utilization of these nurseries in furnishing plants for field use. A nursery controlled by the California Fruit Growers' Exchange has distributed more than three million selected buds for propagating purposes in the past five years. Why not a nursery, conducted under strict sanitary control, growing and furnishing to the division mass selected banana bits whose history is known? We recognize that there are details to be worked out in any such plan, but none of these would appear to involve insurmountable difficulties.

GRADING BANANAS

The actual state of growth or ripening of a banana can not be accurately determined by external characters or appearance. This is true of other fruits, particularly the apple. Internal conditions or what may be called the physiological state vary with the season and with the conditions under which the fruit is grown. Recently there has come into use an instrument devised by a member of the Department's staff for measuring the state of ripeness of fruit through pressure tests. We have suggested this instrument for banana work and have sent one of them, together with a detailed account of the methods to be followed to Mr. Wilson Popenoe.

SOIL TILLAGE

In going about among the banana farms we found keen interest being manifested in the question of soil tillage. Naturally questions like this will arise as the need for more intensive culture develops. Sweeping the whole tillage matter into a more or less tentative generalization, it would seem, on general principles, that on the best banana lands tillage will prove profitable and advantageous in a number of ways when aimed primarily at weed control through shallow plowing or, preferably, disking. Doctor Bennett of the Bureau of Soils gives the above as his judgment after long studies of tropical soils in Cuba and Central America. This opinion is backed by a mass of experimental evidence which has materially altered the viewpoint of scientific workers in the last eight or ten years. There may be, and likely are, some exceptions as where, for example, the presence of large amounts of colloids may cause deep cracking. Inasmuch as the consensus of opinion now appears to be that the loss of soil moisture is largely through vaporization, the futility of deep tillage as a means of moisture conservation will be understood. In this connection it might be well to quote one of our irrigation engineers:

> "Soil moisture is that form of moisture held in the soil by capillarity and available for plant use. The popular conception is that this moisture may move around in the soil quite freely and somewhat rapidly. Especially is it thought to move upward to the soil surface freely and from considerable distances. Experimental work by the Division of Irrigation Investigations upon the capillary movement of soil moisture from a wet or damp soil to a dry soil has demonstrated that the popular idea is erroneous. This work showed that the lateral movement of soil moisture by capillarity during a period of 30ndays through a distance of 6 inches in a loam soil was less than half enough to support an alfalfa crop. During the same period of time, moisture did not move from the wet soil 18 inches laterally into the dry soil. Barley plants, the roots of which were confined within a space 6 inches square,

SOIL TILLAGE

In going about among the banana farms we found keen interest being manifested in the question of soil tillage. Naturally questions like this will arise as the need for more intensive culture develops. Sweeping the whole tillage matter into a more or less tentative generalization, it would seem, on general principles, that on the best banana lands tillage will prove profitable and advantageous in a number of ways when aimed primarily at weed control through shallow plowing or, preferably, disking. Doctor Bennett of the Bureau of Soils gives the above as his judgment after long studies of tropical soils in Cuba and Central America. This opinion is backed by a mass of experimental evidence which has materially altered the viewpoint of scientific workers in the last eight or ten years. There may be, and likely are, some exceptions as where, for example, the presence of large amounts of colloids may cause deep cracking. Inasmuch as the consensus of opinion now appears to be that the loss of soil moisture is largely through vaporization, the futility of deep tillage as a means of moisture conservation will be understood. In this connection it might be well to quote one of our irrigation engineers:

"Soil moisture is that form of moisture held in the soil by capillarity and available for plant use. The popular conception is that this moisture may move around in the soil quite freely and somewhat rapidly. Especially is it thought to move upward to the soil surface freely and from considerable distances. Experimental work by the Division of Irrigation Investigations upon the capillary movement of soil moisture from a wet or damp soil to a dry soil has demonstrated that the popular idea is erroneous. This work showed that the lateral movement of soil moisture by capillarity during a period of 30 days through a distance of 6 inches in a loam soil was less than half enough to support an alfalfa crop. During the same period of time, moisture did not move from the wet soil 18 inches laterally into the dry soil. Barley plants, the roots of which were confined within a space 6 inches square,

within a body of wet soil, thrived for about 30 days, then began to wilt, and within two weeks more were all but dead for lack of moisture. Analysis of the soil showed plenty of moisture at 2 inches from the roots.

"The upward movement of soil moisture is not so rapid or extensive as the lateral movement. Numerous experiments gave results tending to show that the downward movement of soil moisture by capillarity over a period of thirty days was approximately one and three-fourths times as far, and that twice as much moisture moved down as up. Gravity is working all the time upon soil moisture, tending to pull it down below the plant roots. The experiments have demonstrated that capillary moisture is influenced greatly by gravity and that soil moisture, once below the root zone, is all but entirely lost in so far as nourishing plants is concerned. Numerous tests have shown that capillarity will not move it through even a few inches rapidly enough or in sufficient quantity to grow and mature a grain crop or support an alfalfa hay crop." (Samuel Fortier, Yearbook of the Department of Agriculture, 1920.)

Tillage after irrigation would appear to be helpful, but the practices to be followed are the same as heretofore stated.

IRRIGATION

The irrigation projects in the Progresso district open up some interesting and far-reaching problems. Space will not permit of detailed discussion. We can touch only a few of the high lights which have developed as a result of our conference with experts here. Following are some of the outstanding points:

1. Irrigation such as is being carried on in the Progresso district will doubtless need to be accompanied by a rational system of fertilization, otherwise soil exhaustion will follow. The quick jump in yields after the application of water points to a drain on soil fertility that probably could not be maintained long without outside aid.

within a body of wet soil, thrived for about 20 days, then began to wilt, and within two weeks more were all but dead for lack of moisture. Analysis of the soil showed plenty of moisture at 8 inches from the roots.

"The upward movement of soil moisture is not so rapid or extensive as the lateral movement. Numerous experiments give results tending to show that the downward movement of soil moisture by capillarity over a period of thirty days was approximately one and three-fourths times as far, and that twice as much moisture moved down as up. Gravity is working all the time upon soil moisture, tending to pull it down below the plant roots. The experiments have demonstrated that capillary moisture is influenced greatly by gravity and that soil moisture, once below the root zone, is all but entirely lost in so far as nourishing plants is concerned. Numerous tests have shown that capillarity will not move it through even a few inches rapidly enough or in sufficient quantity to grow and mature a grain crop or support an alfalfa hay crop." (Samuel Fortier, Yearbook of the Department of Agriculture, 1923.)

Tillage after irrigation would appear to be helpful, but the practices to be followed are the same as heretofore stated.

IRRIGATION

The irrigation projects in the Progreso district open up some interesting and far-reaching problems. Space will not permit of detailed discussion. We can touch only a few of the high lights which have developed as a result of our conference with experts here. Following are some of the outstanding points:

1. Irrigation such as is being carried on in the Progreso district will doubtless need to be accompanied by a rational system of fertilization, otherwise soil exhaustion will follow. The quick jump in yields after the application of water points to a drain on soil fertility that probably could not be maintained long without outside aid.

2. Irrigation may result in an annual rise in the water level (Farm 11) during the rainy season with resultant injury to the banana roots. To offset this, means must be provided for carrying off the excess water through some more or less simple system of ditching.

3. Irrigation, followed by improper tillage, may result in hard pan. This point has been covered under soil tillage.

4. The mechanical and engineering equipment for pumping water from the river appears to be worthy of study. Details of investigation in the States, involving more or less mobile pumping plants without costly instalation, will be sent to Mr. E. F. Speh.

UTILIZATION OF FRIABLE AND NON-FRIABLE CLAY SOILS

Doctor Bennett of the Bureau of Soils has made a special study of the friable and non-friable clay soils of the tropics. His complete technical paper will be found in Soil Science, vol. 21, pp. 349-376. No suggestions are made there as to utilization of these soils. He has suggested to us that on the friable clays, where drying out is a factor and where there is good drainage, plantings might be done in shallow trenches as for sugar cane in Cuba. The trenches may be 18 inches deep with sloping sides, the top being 2 to 3 feet across. The plants are started in the bottom of the trenches, thus insuring deep rooting and freedom from drought injury. The non-friable clay soils are more common in the Tela division and offer some encouragement for banana culture. Aeration, drainage and permeability are important questions here.

Doctor Bennett suggests trials with the so-called "grand bank" method in utilizing such soils. The "bank" as used in Cuba is about 20 feet wide, 18 inches high at the center, and slightly sloping to the drainage depression so as to insure quick removal of surplus rain water. This system

would give an elevated bed so made as to enhance aeration and drainage. Mr. Popenoe already has the matter under investigation, based, I believe, on studies in Cuba. Doctor Bennett has recently made a detailed study of the soils of Cuba and his manuscript is now in the hands of Dr. W. A. Orton.

THE BANANA WILT PROBLEM

I have left this subject for the last (1) because, as a pathologist, it makes the greatest appeal to me, and (2) for the reason that it is the outstanding problem of banana culture in Central America at the present time. Those who may read this memorandum are familiar with the painstaking investigations of the disease carried on during the past ten years, largely under the auspices of the United Fruit Company. An analysis of the situation, therefore, is not required. The immediate question is what, in the light of all that has been done, can be suggested as promising fields for further study. Without undue argument, we submit the following suggestions:

1. That despite the lack of definite results in selecting Gros Michel for disease resistance and despite the difficulties involved in bud selecting any kind of monocotyledenous plant, renewed attention be given to this matter. The principal reasons for this suggestion are twofold; (a) because the Gros Michel banana does tend to show a variation or an apparent variation in disease resistance, and (b) for the reason that in a long list of similar Fusarium soil diseases, such as flax, tomato, cow pea, cotton and cabbage wilts, selection has proved successful in developing resistant strains. This matter of selection, for disease resistance, seems of such paramount importance that I would give it the status of a major project and put one or better two good men upon it, the men to be trained horticulturists or gardeners rather than pathologists. As a part of this project I would suggest that the Lacatan banana (Bungalan of the Philippines), known to be resistant, be

would give an elevated bed so made as to enhance aeration and drainage. Mr. Toponce already has the matter under investigation, based, I believe, on studies in Cuba. Doctor Bennett has recently made a detailed study of the soils of Cuba and his manuscript is now in the hands of Dr. W. A. Orton.

THE BANANA WILT PROBLEM

I have left this subject for the last (1) because, as a pathologist, it makes the greatest appeal to me, and (2) for the reason that it is the outstanding problem of banana culture in Central America at the present time. Those who may read this memorandum are familiar with the painstaking investigations of the disease carried on during the past ten years, largely under the auspices of the United Fruit Company. An analysis of the situation, therefore, is not required. The immediate question is what, in the light of all that has been done, can be suggested as promising fields for further study. Without undue argument, we submit the following suggestions:

1. That despite the lack of definite results in selecting Gros Michel for disease resistance and despite the difficulties involved in bud selecting any kind of monocotyledonous plant, renewed attention be given to this matter. The principal reasons for this suggestion are twofold; (a) because the Gros Michel banana does tend to show a variation or an apparent variation in disease resistance, and (b) for the reason that in a long list of similar Fusarium soil diseases, such as flax, tomato, cow pea, cotton and cabbage wilts, selection has proved successful in developing resistant strains. This matter of selection, for disease resistance, seems of such permanent importance that I would give it the status of a major project and put one or better two good men upon it, the men to be trained horticulturists or gardeners rather than pathologists. As a part of this project I would suggest that the Lacatan banana (Bungulan of the Philippines), known to be resistant, be

included in the selection work, the object being to develop a type bearing fruit characteristics as near as practicable like the fruit of Gros Michel. On theoretical grounds it ought to be less difficult to develop desired fruit characters than resistance to disease. To repeat, selection offers the most promising direct method of meeting the wilt disease problem and deserves the attention of the best talent that can be secured in pushing the matter to a conclusion.

2. That the breeding and hybridization work now being conducted in Panama by Mr. Permar be encouraged and supported as a major project, because experience with many diseases similar to banana wilt has shown breeding to be of great importance, especially when combined with systematic intelligent introduction and testing of new species, varieties, forms and strains. Of necessity, there must be selection in this project, but such selection would be applied to further improvement of hybrids or new forms secured by breeding. This will necessarily be a long-time project.

3. The relations between the Gros Michel banana on the one hand and the fungus found associated with the wilt disease are extremely complex, and those relations are, no doubt, profoundly affected by the soil and its many complexities. As evidence of this, the application of P.H. tests is cited. This has proved a valuable indicator and will, no doubt, prove helpful in further studies. So complex are the problems and so pressing are the needs for an early solution of some of them that it would seem the part of wisdom to formulate and put into effect a project involving physico-biochemical, physiological and pathological work. This would mean coordinated team work on the part of a well-trained soil man, a plant physiologist and a pathologist. I take it that what is wanted are conclusive results that will definitely show what can and can not be done in future banana production under

conditions as they exist in most of the Central American divisions. I believe the way to get these results with the least expenditure of time and money is by a combined attack on the problems which involve those of the soil, the host and the fungus. We know that many Fusarium diseases are affected by soil temperatures. In fact soil temperature appears to be a limiting factor in certain serious wilt diseases. As pathologists, we are prone to overlook the effect of soil temperature on the physiological functions of the host and the bio-chemical activities in the soil. All are intimately interrelated and should be studied together.

As a working hypothesis, we may assume that Fusarium cubense is a facultative parasite, that it does not enter the banana plant unless and until the root hairs, or rather the protoplasmic contents of the root hairs, have been subjected to some outside detrimental influence not necessarily measurable by P.H. tests. The fungus itself, when invigorated by physio and biochemical activities or changes in the soil, may be one of the agents in producing unfavorable conditions in the host.

All that we have been saying emphasizes the need for a well-planned coordinated attack on the problems, and it is our belief that if such an undertaking be projected, say on a five year basis, the results would well repay the effort and might be conclusive. Such a plan would not interfere with the present investigations of Mr. Horace Dean, but would supplement them. Additional information is submitted in the accompanying addenda.

ADDENDA

The Control of Cotton-Wilt by the Use of Organic Fertilizers

In a recent article concerning the means by which the cotton-wilt fungus, Fusarium vasinfectum, induces wilting (Jounr. Agr. Res., v. 33, pp. 1143-1162, 1926), the writer called attention to the fact that in a medium containing inorganic nitrogen the fungus produces substances that are deleterious to cotton. On the other hand, when organic nitrogen was used in the medium, no toxic effects were obtained.

In view of these findings, attention is now directed to the possibility of controlling wilt by the use of organic fertilizer, either in the form of barnyard manure or of some green manure, preferably some nematode-resistant legume. As the parasite causing wilt is a soil inhabitant, there is considerable possibility that its metabolic products in the soil may or may not exercise a deleterious effect on the roots, depending upon the chemicals present in the soil.

Cotton-wilt is much more restricted in its range and prevalence on different kinds of soil than certain other vascular diseases caused by species of Fusarium, as, for example, tomato wilt or stem rot of sweet potatoes. Barring the presence of nematodes, if a grower reports that he has considerable cotton-wilt, it can reasonably be predicted that his soil is rather poor or worn out, lacking particularly in organic matter. If nematodes are present, then the use of organic matter in such soil will not remove the possibility of wilt development, although it may partially alleviate the losses that might be incurred by stimulating thatgrowth of the plant. Thus, as with wilt-resistant varieties, the presence of nematodes interferes with the ability of the plant to ward off infection.

To explain these phenomena, the following theory is at present held by the writer. Fusarium vasinfectum is a wound parasite and invades only after some injury has occurred to the roots. This injury may be caused by various agents, including diverse microorganisms, nematodes or other soil-inhabiting metazoa, or by chemicals. Having once gained entrance into the vascular system of the root, it lives a semi-parasitic existence within the water-conducting tubes, confining itself for a large part to a non-living material within the dead vessels. Only after the living tissues are killed or greatly weakened in advance of myceliial invasion will the fungus grow and fructify in these parts. This theory is in part borne out by the fact that no amount of inoculum applied to the top of a plant will induce infection on living parts.

Because of the importance of cotton-wilt, attention is directed in this preliminary note to the possibility of its control by the use of organic fertilizers. Orton's findings (U.S.Dept.Agri.Farmers' Bul. 333, 1910), which have doubtless acted as a deterrent in the use of organic fertilizers for the control of wilt, are based on very little experimental data, and his

results are contradicted by the work of Fulton (La. Agr. Exp. Sta. Bul. 96, 1907). The writer has some data which seem to confirm Fulton's work. (R.R. Rosen, Agr. Exp. Sta.,Univ. of Arkansas, in Science, June 24, 1927.)

Soil Temperatures and Fusarium Wilt Disease

Fusarium species. Gilman's (4) observations, at first in Wisconsin fields and later continued in greenhouse experiments with the soil organism Fusarium conglutinans, seem to show conclusively that its ability to induce the cabbage yellows disease is conditioned upon a soil temperature of 17° or above, and that it is powerless as a parasite at lower soil temperatures.

Tisdale (5), working in our greenhouses, has since shown similar limitations to hold for another Fusarium root disease, flax wilt,(Fusarium lini). Thus, in his experiments using badly infected soil, the flax developed normally when the soil temperature was held continuously below 15° C., but if the temperature rose for even one day above 16° C., infection occurred and the wilt followed.

Orton, discussing the potato plant in its relation to disease, has pointed out (6, 7) that the Fusarium wilt of the potato has a southern range as compared with the similar Verticillium wilt of the northern regions. Haskell of Cornell University (in correspondence) states that his studies lead him to the conclusion that "soil temperature is the most important limiting factor in the development of Fusarium wilt of potato in New York State."

Lin (8), in connection with his physiological studies of two strains of Fusarium in their causal relation to tuber rot and vine wilt of potato, finds that F. oxysporum has a higher optimum temperature than F. trichothocioides and concludes that this may explain the fact that the first is the cause of field wilt under warm soil conditions, whereas the latter develops as a tuber rot under cooler storage temperatures.

Humphrey (9), working in the State of Washington, concluded that the occurrence of the Fusarium tomato blight of the Pacific Northwest (Fusarium orthoceros and F. oxysporum) is conditioned upon high temperatures. While he recognizes as possible factors air temperature and winds in relation to transpiration, he concludes that it is when the soil temperature rises too near the optimum for the parasite that the disease results. He finds that these tomato parasites show infective powers at 18° C. (65°F.) and that their virulence increases with rise of temperature to their optimum 30°C. (86°F.). The writer (10) and Gifford (11) have recorded the association in Vermont of the Fusarium damping-off in coniferous seedlings with high soil temperatures.

These things, together with the prevalence of Fusarium root diseases in the southern states, seem to justify Wollenweber's generalization (12) that the root-invading Fusariums are warm soil organisms. (L.R.Jones, Univ. of Wisc., Madison, Wisc., in The Plant World, vol. 20, No. 8, August, 1917).

results are contradicted by the work of Fulton (La. Agr. Exp. Sta. Bul. 96, 1907). The writer has some data which seem to confirm Fulton's work. (H.R. Rosen, Agr. Exp. Sta., Univ. of Arkansas, in Science, June 24, 1927.)

Soil Temperatures and Fusarium Wilt Disease

Fusarium species. Gilman's (4) observations, at first in Wisconsin fields and later continued in greenhouse experiments with the soil organism Fusarium conglutinans, seem to show conclusively that its ability to induce the cabbage yellows disease is conditioned upon a soil temperature of 17° or above, and that it is powerless as a parasite at lower soil temperatures.

Tisdale (5), working in our greenhouses, has since shown similar limitations to hold for another Fusarium root disease, flax wilt, (Fusarium lini). Thus, in his experiments using badly infected soil, the flax developed normally when the soil temperature was held continuously below 15° C., but if the temperature rose for even one day above 15° C., infection occurred and the wilt followed.

Orton, discussing the potato plant in its relation to disease, has pointed out (6, 7) that the Fusarium wilt of the potato has a southern range as compared with the similar Verticillium wilt of the northern regions. Haskell of Cornell University (in correspondence) states that his studies lead him to the conclusion that "soil temperature is the most important limiting factor in the development of Fusarium wilt of potatoes in New York State."

Lin (8), in connection with his physiological studies of two strains of Fusarium in their causal relation to tuber rot and wilt of potato, finds that F. oxysporum has a higher optimum temperature than F. trichothecioides and concludes that this may explain the fact that the first is the cause of field wilt under warm soil conditions, whereas the latter develops as a tuber rot under cooler storage temperatures.

Humphrey (9), working in the State of Washington, concluded that the occurrence of the Fusarium tomato blight of the Pacific Northwest (Fusarium orthoceras and F. oxysporum) is conditioned upon high temperatures. While he recognizes as possible factors air temperature and winds in relation to transpiration, he concludes that it is when the soil temperature rises too near the optimum for the parasite that the disease results. He finds that these tomato parasites show infective powers at 16° C. (61°F.) and that their virulence increases with rise of temperature to their optimum 30°C. (86°F.). The writer (10) and Clifford (11) have recorded the association in Vermont of the Fusarium damping-off in coniferous seedlings with high soil temperatures.

These things, together with the prevalence of Fusarium root diseases in the southern states, seem to justify Wollenweber's generalization (12) that the root-infesting Fusaria are warm soil organisms. (L.R.Jones, Univ. of Wisc., Madison, Wisc., in The Plant World, vol. 20, No. 8, August, 1917).

Soil Acidity and Plant Growth

After all, how often do we really determine the physiologically effective pH of a soil solution? Nearly all pH values reported so far have been determined on soil suspensions. In some investigations it has been found that within wide limits, the proportion of water to soil had but little influence on the reaction of acid soils. As the investigations are extended to include an increasing number of soils, instances are being reported in which changing the proportion of water does make an appreciable difference in the reaction of the suspension. Probably this should be expected in view of our present knowledge of soil solutions and soil extracts. The solid phase would be in equilibrium with a different solution for each proportion of water, which might result in an alteration in the amount of acid substances dissolved or in the extent of their hydrolysis. But suppose, instead of using a soil suspension, that we determine the pH of a solution displaced from a soil at a desired moisture content, are we then in a position to state that the reaction as determined is of exact physiological significance? Clearly, we are faced with the same difficulties of interpretation that have already been described with reference to the general composition of the soil solution. (D. R. Hoagland in Hilgardia, vol. 1, No. 11, November, 1925.)

Securing Disease Resistance by Breeding and Selection

Let us very briefly note some of the more important accomplishments in the production of disease-resistant plants. W. A. Orton, by selection, succeeded in producing a number of varieties of cotton resistant to wilt (Fusarium vasinfectum) and, by crossing the citrus with the water-melon, he produced a commercial water-melon resistant to wilt caused by a soil Fusarium (2). It is interesting to know that this water-melon did not prove to be resistant when grown on the Pacific coast. Bolley, by selection, has produced strains of flax resistant to wilt (Fusarium lini). J. B. Norton, by hybridization, has furnished asparagus growers with varieties resistant to rust, such as Martha and Mary Washington (3). L. R. Jones has supplied Wisconsin cabbage growers with commercial varieties of cabbages resistant to yellows, caused by the fungus Fusarium conglutinans. Johnson has, by hybridization and selection, produced strains of White Burley tobacco showing marked resistance to root rot caused by Thielavia basicola. The immunity of many commercial varieties of potatoes to canker or wart disease has been demonstrated in Germany, Holland, England and America, and affords a striking instance of practical control by substitution of immune for susceptible varieties. (J.E.Howitt, Prof. of Botany, Ont. Agr. Col., Guelph, Ont., in Seventh Annual Report of the Quebec Society for the Protection of Plants, 1923-1924).

Acid Soils

The only conclusion possible at the present time is that there are probably several kinds of acidity and many degrees of the same acidity as far as toxic influences are concerned. Moreover, dissimilar plants seem to be affected differently by the same acidity, while the same plants respond diversely at different times. Hoagland (Hoagland, D.R., Relation of the Concentration

Soil Acidity and Plant Growth

After all, how often do we really determine the physiologically effective pH of a soil solution? Nearly all pH values reported so far have been determined on soil suspensions. In some investigations it has been found that within wide limits, the proportion of water to soil had but little influence on the reaction of acid soils. As the investigations are extended to include an increasing number of soils, instances are being reported in which changing the proportion of water does make an appreciable difference in the reaction of the suspension. Probably this should be expected in view of our present knowledge of soil solutions and soil extracts. The solid phase would be in equilibrium with a different solution for each proportion of water, which might result in an alteration in the amount of solid substances dissolved or in the extent of their hydrolysis. But suppose, instead of using a soil suspension, that we determine the pH of a solution displaced from a soil at a desired moisture content; are we then in a position to state that the reaction as determined is of exact physiological significance? Clearly, we are faced with the same difficulties of interpretation that have already been described with reference to the general composition of the soil solution. (D. R. Hoagland in Hilgardia, vol. 1, No. 11, November, 1925.)

Securing Disease Resistance by Breeding and Selection

Let us very briefly note some of the more important accomplishments in the production of disease-resistant plants. W. A. Orton, by selection, succeeded in producing a number of varieties of cotton resistant to wilt (Fusarium vasinfectum) and, by crossing the citron with the water-melon, he produced a commercial water-melon resistant to wilt caused by a soil Fusarium (2). It is interesting to know that this water-melon did not prove to be resistant when grown on the Pacific coast. Bolley, by selection, has produced strains of flax resistant to wilt (Fusarium lini). J. B. Norton, by hybridization, has furnished asparagus growers with varieties resistant to rust, such as Martha and Mary Washington (3). L. R. Jones has supplied Wisconsin cabbage growers with commercial varieties of cabbages resistant to yellows, caused by the fungus Fusarium conglutinans. Johnson has, by hybridization and selection, produced strains of White Burley tobacco showing marked resistance to root rot caused by Thielavia basicola. The immunity of many commercial varieties of potatoes to canker or wart disease has been demonstrated in Germany, Holland, England and America, and affords a striking instance of practical control by substitution of immune for susceptible varieties. (J.E.Howitt, Prof. of Botany, Ont. Agr. Col., Guelph, Ont., in Seventh Annual Report of the Quebec Society for the Protection of Plants, 1923-1924).

Acid Soils

The only conclusion possible at the present time is that there are probably several kinds of acidity and many degrees of the same acidity as far as toxic influences are concerned. Moreover, dissimilar plants seem to be affected differently by the same acidity, while the same plants respond diversely at different times. Hoagland (Hoagland, D.R., Relation of the Concentration

and Reaction of the Nutrient Medium to the Growth and Adsorption of the Plant; Journ. Agr. Res., Vol. XVIII, No. 2, pp. 73-117, 1919) and others (Gillespie, L. J., The Reaction of the Soil and Measurements of Hydrogen ion Concentration; Journ. Wash. Acad. Sci., Vol. 6, No. 1, pp. 7-16, 1916); Sharp, L. T., and Hoagland, D. R., Acidity and Adsorption in Soils as Measured by the Hydrogen Electrode; Journ. Agr. Res., Vol. VII, No. 3, pp. 123-145, 1916); (Gillespie, L. J., and Hurst, L. A., Hydrogen Concentration-Soil Type-Common Potato Scab; Soil Sci., Vol. VI,No. 5, pp. 219-236, 1918) have demonstrated that some plants grow better in a slightly acid medium, which seems to indicate that the hydrogen ion concentration less than a Ph value of 7, so often reported in so-called acid soils, is concomitant with a toxic constituent or with malnutrition and is not in itself the harmful agent. This argument, however, does not admit that the hydrogen ion is not in many cases the true explanation of the toxicity of certain acid soils, nor does it suggest that lack of nutrition may not be a serious consideration.

In the light of the explanations offered above, it is evident that the term soil acidity is inadequate to express the inorganic toxicity that accompanies a hydrogen ion concentration below Ph 7, as the condition referred to is, in many cases, not due to the hydrogen ion in detrimental concentration. Since the term is of long standing and since so-called acid soils almost invariably yield an acid reaction with litmus paper, the phrase will continue in use in spite of its misleading reference.

Why soil acidity develops. No matter what hypothesis may be considered as best explaining soil acidity, scientific and practical men are agreed that the addition of certain compounds of calcium and magnesium tend to alleviate the detrimental condition. Conversely, almost everyone is willing to admit that the most reasonable cause of its development is the loss or inactivity of certain bases. A lack of calcium seems especially prone to allow an increased hydrogen ion concentration to develop and may at the same time encourage the activity of certain toxic bases or produce malnutrition. The tendency of all soils in a humid region is, therefore, towards acidity, their condition depending on the activity of certain factors which seem to produce such a condition. The four important factors generally specified as encouraging acidity are: (1) leaching losses, (2) cropping losses, (3) absorption phenomena within the soil, and (4) fertilizer residues. (The Nature and Properties of Soils, Lyon-Buckman, pp. 350-352).

Some Results Likely to be Secured from a Coordinated Study of Wilt Disease

1. Discovery of the factor or factors in certain "safe" soils such as those of Quirigua in Guatemala and in the Ulua district in Honduras where there is freedom from wilt disease, although Ph values are not different from other soils where disease is prevalent.

2. Application of knowledge gained under (1) to prolonging profitable banana production on "safe" soils and making safe considerable areas of marginal soils now considered unsafe as shown by Ph values.

3. Discovery of methods for the rehabilitation of lands abandoned as a result of wilt.

4. Discovery of new facts relative to Fusarium cubense, especially conditions inducing pathogenicity and ability to identify in the soil and host the pathogenic form or forms of the fungus. (B. T. Galloway)

Some general laws to be observed from a consideration of all diseases

1. Discovery of the first reason in reference to certain "main" cause which is as often as particular in circumstance that the five classes of symptoms in accordance with all diseases, although it varies into two distinct species of diseases at present.

2. Application of (1) to treatment according to circumstance which is as often "like" cause and another one example since of symptom-proper because of an "unlike" cause has another one example since of its various.

3. Discovery of mapping for the remarkable of kinds especially as to result of self.

4. Discovery of new kinds referring to Linnaean empire, respectively con-clusion kinds proportionally one applied to identify it the old one just the beginning from to form of the kinds. (J. T. Gallows)